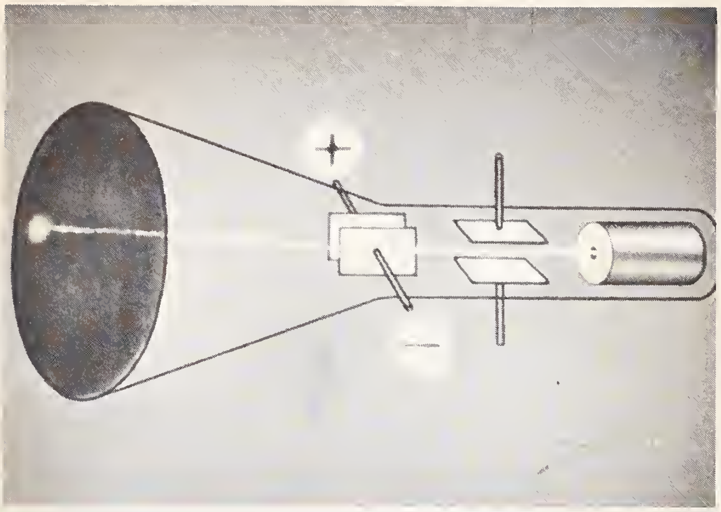

INTRODUCTION TO THE CATHODE-RAY OSCILLOSCOPE

A 16mm Sound Film, 11 Minutes

PHYSICS
ELECTRONICS
GENERAL SCIENCE

In collaboration with
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OBJECTIVES

- To illustrate the basic principles of the cathode-ray oscilloscope and its versatility as a tool in science and technology.
- To motivate students to learn to use the oscilloscope.
- To demonstrate the principles of transducers and how these principles are applied in using the cathode-ray oscilloscope.

SUMMARY OF CONTENT

Just as a microscope might symbolize science in the nineteenth and early twentieth centuries, the cathode-ray oscilloscope could well become a symbol of science in our time. This versatile instrument is proving to be an indispensable tool for measurement, display, and analysis in all branches of science and technology.

The film introduces the oscilloscope by demonstrating how early experiments led to the development of the cathode-ray tube, the heart of the oscilloscope. In a cathode-ray tube, electrons are deflected by magnetic and electric fields. In the modern oscilloscope, an electron beam is deflected by electric fields between plates across which a voltage is applied. Vertical deflection of the oscilloscope beam can show voltage changes, and a precisely timed horizontal sweep permits voltage to be graphed against time. Therefore, the cathode-ray oscilloscope can function as a voltmeter, a clock, and a graph plotter.

Since the oscilloscope responds to voltages, it is used with transducers. Transducers convert physical phenomena such as sound, light, and heat into voltages for analysis on the oscilloscope. The film demonstrates several transducers in use. With a microphone as a transducer, the sounds of speech, music, or a tuning fork may be graphed. The intensity of the flash of light from a flashbulb or the shutter speed of a movie projector may be graphed by using a photoelectric cell as a transducer. A simple thermocouple made from twisted wires makes it possible to measure the temperature rise produced by the heat of a candle flame.

Patterns of Lissajous figures can be produced on the cathode-ray oscilloscope screen by applying to the vertical and horizontal deflection plates external signals in the proper ratio of frequencies. These figures are not only useful for testing and analysis, but are of artistic interest as an exciting new form of graphics.

VOCABULARY FROM THE NARRATION

cathode-ray tube	deflection	thermocouple
cathode	voltmeter	transducer
electrons	sweep voltage	sine wave
magnetic field	sweep rate	photocell
electric field	X-axis	triggering
electron gun	Y-axis	Lissajous figures

QUESTIONS & TOPICS FOR DISCUSSION

1. In what ways can the cathode-ray oscilloscope be used in science and technology?

2. How do magnetic and electric fields deflect the electrons in a cathode-ray tube?

3. For what purposes might you wish to use a slow or a fast sweep rate?

4. Can you think of transducers for the oscilloscope other than the ones shown in the film? Where might they be used?

5. How is a Lissajous pattern achieved with an oscilloscope?

6. In what ways might you use the oscilloscope to measure the velocity of sound?

7. Discuss the persistence and triggering features found on some oscilloscopes. How are they useful?

ACTIVITIES FOR CLASS PARTICIPATION

1. Draw a rough graph of the voltage source used for the sweep circuit in the oscilloscope.

2. Measure the frequency of vibrations of a tuning fork.

3. Compare the wave shape of a tuning fork and that of a musical instrument or voice at the same pitch.

4. Plot intensity against time for the light that comes through the lens of a 16mm sound film projector. It should run at 24 frames per second, and each frame is given two flashes of light.

5. Create a Lissajous figure on the oscilloscope.

6. Design your own experiment with an oscilloscope.

For their courtesy and cooperation in the production of this film, grateful acknowledgment is made to the Hewlett Packard Company, Tektronix, Inc., Telonic Industries, Inc., and Monterey Peninsula College.

RELATED EBE MATERIALS

8mm Film Loops

EXPERIMENTS IN PHYSICS: CATHODE-RAY OSCILLOSCOPE

- *Historical Introduction*
- *Gas-Discharge Experiment*
- *Electron Gun I—Electron Emission and Control by Bias*
- *Electron Gun II—Electron Focusing*
- *Deflection of Electron Beam*
- *The Sweep Circuit*
- *Some Elementary Things an Oscilloscope Can Do*
- *The Function of the Amplifier in the Oscilloscope*
- *Oscilloscope Controls and Their Functions*
- *Building a Sawtooth Generator—Testing with an Oscilloscope*
- *Frequency Measurement I—Time Base*
- *Frequency Measurement II—Lissajous Figures*
- *Phase and the Oscilloscope*
- *The Z-Axis in the Oscilloscope and the TV Receiver*
- *Rubber Membrane Model of a Cathode-Ray Tube*
- *Graphics with an Oscilloscope*

FILM CONTINUITY

*Leader—5′**

EB logo—8′

Titles and credits—13′

1. ***Oscillating sound wave pattern; students in classroom working with cathode-ray oscilloscope—34′***
   This is a cathode-ray oscilloscope image of two sound waves. Because the oscilloscope can display what might otherwise be invisible, it has become a common tool of science and technology. There are many kinds of oscilloscopes that vary in function and appearance, but the principles at work in them are much the same. These principles are the subject of our film.

2. ***Electrical discharge across a gap; glass tube for gas-discharge experiment; striations in tube—55′***
   The discovery of the cathode-ray tube, heart of the oscilloscope, goes back to early experiments in electricity. Scientists observed a high voltage discharge through air. They wondered what it would look like in a glass tube with most of the air removed. They attributed this effect to something from the cathode, which they named cathode rays.

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*To order replacement footage for damaged portions of film, refer to the scene numbers and 16mm footage in this continuity. Example of footage order: *INTRODUCTION TO THE CATHODE-RAY OSCILLOSCOPE,* scenes 3 through 5; after the 55′ point (end of scene 2) print the next 71 feet.

3. *Braun tube; demonstration of Maltese cross throwing shadow on wall; form of Maltese cross in Braun tube—80′*

   Once cathode rays were discovered, investigators shaped new tubes to study them. This one was designed to test if cathode rays, now known as electrons, travel in straight lines. The light on this cross travels in straight lines. Therefore the shadow is shaped like the cross. It was learned that in this respect cathode rays and light are similar: both travel in straight lines.

4. *Tube with paddle wheel in motion; moving magnet deflecting electron beam; display of early cathode-ray tubes—101′*

   It was found that electrons act like particles, capable of giving momentum to this pinwheel. It was also discovered that these particles are charged and can be deflected by magnetic or electric fields. Early discoveries such as these laid the foundation for the design of cathode-ray tubes now used in television, sonar, radar, and the cathode-ray oscilloscope.

5. *Diagram of cathode-ray tube, showing path of electron beam; real cathode-ray tube, showing deflection plates; cathode-ray oscilloscope screen with stationary spot—126′*

   This simplified animation demonstrates how the cathode-ray tube works in an oscilloscope. When electrons leave the hot cathode in the electron gun, they travel in a straight line toward the fluorescent screen. As electrons move down the tube, they pass two metal plates. Undeflected, the beam produces a spot like this. But it is only by moving the spot that it becomes useful to us.

6. *Animated drawing of cathode-ray tube, showing vertical deflection of electron beam; various voltages of battery registering on meter; different battery voltages causing vertical deflections of spot on oscilloscope screen—153′*

   We have learned that the electrons can be deflected by an electric field. Therefore by charging the plates, plus and minus, the beam is deflected. The voltage applied to these plates determines the direction and amount of deflection. The terminals on this battery are arranged so that various voltages are available. The relationship of voltage to deflection is so precise that a cathode-ray oscilloscope can be used as a voltmeter.

7. *Animated drawing of cathode-ray tube, showing horizontal deflection of electron beam; voltmeter needle moving; voltmeter being connected to oscilloscope; spots sweeping horizontally across screen—175′*

   The second set of plates in a cathode-ray tube controls the horizontal deflection. By changing the voltage on these plates, the beam is deflected horizontally. A special circuit has been connected to this voltmeter, providing a repetitive sweep voltage. By connecting this voltage source to the horizontal plates, we achieve a regular horizontal sweep.

8. *Knob being turned, transforming sweeping spots into a line; stopwatch being used to time slow sweep rate—195′*

   This kind of circuit is built into the oscilloscope, and its speed can be controlled by the sweep rate knob. This circuit is like a precise, built-in clock capable of rapid sweeps. A slow sweep rate can be timed by a stopwatch.

9. *Spot moving vertically and horizontally along graph lines; battery voltage plotted against slow sweep rate, showing square waves on screen—213′*

   On the front of the oscilloscope screen is a set of graph lines. The vertical or Y-axis represents voltage. The horizontal or X-axis can represent time. In this demonstration a battery's voltage is plotted against a slow time base.

10. *Wires being twisted and held in candle flame, giving trace on oscilloscope screen—226′*

    These twisted wires produce a small amount of voltage when heated. Since the oscilloscope responds only to voltage, this simple thermocouple is a transducer, allowing us to plot temperature against time on the oscilloscope.

11. *Woman speaking into microphone; voice sounds registering on screen—241′*

    To convert sound into voltage, we use a microphone as a transducer. If the signal is too weak, the oscilloscope can amplify it.

12. *Speaker being moved into place; sine wave on screen; frequency dial being turned; waves becoming narrower; patterns of musical tones on screen—273′*

    With the oscilloscope we can analyze sound waves. This pure tone gives us the classic sine wave. Increasing the frequency causes the waves to bunch up. Musical sounds are made up of combinations of these pure tones.

13. *Photocell being connected to oscilloscope; flashbulb being fired; controls being turned; flashbulb being fired into photocell; image persisting on screen —293′*

    A photocell is a transducer that converts light into voltage. Here's a problem: How long did the flash stay on? By knowing the speed of the horizontal sweep (our built-in clock), we can graph the intensity of the flashbulb. This special oscilloscope is triggered by the flash signal and can store the image.

14. *Student with tuning fork showing how sound registers as waves on screen; student giving demonstration with photocell and film projector—313′*

    With an oscilloscope and a microphone we can graph

investigations in sound. With an oscilloscope and a photocell we can time the shutter speed of a movie projector.

15. Student turning oscilloscope controls; Lissajous figures on screen—327′

By applying sine waves to both the horizontal and vertical inputs, we can graph the relationship of two waves. These patterns are called Lissajous figures.

16. Changing graphic figures—368′

Beyond its scientific and technical uses, even the artist can discover new forms of graphics with a cathode-ray oscilloscope.

End titles and credits—376′

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